CLAIMS:

We Claim:

1. A vehicle including a system for determining the occupancy state of a seat in the vehicle occupied by an occupying item, the system comprising:

a plurality of transducers arranged in the vehicle, each of said transducers providing data relating to the occupancy state of the seat; and

processor means coupled to said transducers for receiving the data from said transducers and processing the data to obtain an output indicative of the current occupancy state of the seat, said processor means comprising a combination neural network created from a plurality of data sets, each of said data sets representing a different occupancy state of the seat and being formed from data from said transducers while the seat is in that occupancy state,

said combination neural network producing the output indicative of the current occupancy state of the seat upon inputting a data set representing the current occupancy state of the seat and being formed from data from at least some of said transducers.

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2. The vehicle of claim 1, wherein said combination neural network comprises a neural network trained to determine the type of the occupying item based on data from at least some of said transducers.

3. The vehicle of claim 1, wherein said combination neural network comprises a neural network trained to determine the size of the occupying item based on data from at least some of said transducers.

4. The vehicle of claim 1, wherein said combination neural network comprises a neural network trained to determine the position of the occupying item based on data from at least some of said transducers.

5. The vehicle of claim 1, wherein said combination neural network comprises a first neural network trained to determine the type of the occupying item based on data from at least some of said transducers and a second neural network trained to determine the size of the occupying item based on data from at least some of said transducers.

6. The vehicle of claim 5, wherein said combination neural network further comprises a plurality of additional neural networks, each trained to determine the position of the occupying item for a particular size of occupying item based on data from at least some of said transducers, one of said plurality of additional neural networks determining the position after said second neural network determines size.

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7. The vehicle of claim 6, wherein said combination neural network comprises a feedback loop wherein the determination of the position at one instance is used as input into one of said plurality of additional neural networks at a subsequent instance.

8. The vehicle of claim 1, wherein said combination neural network comprises a feedback loop wherein the determination of the occupancy state at one instance is used as input into said combination neural network at a subsequent instance.

9. The vehicle of claim 1, wherein said combination neural network comprises a first neural network trained to identify the occupying item based on data from at least some of said transducers and a second neural network trained to determine the position of the occupying item based on data from at least some of said transducers.

10. The vehicle of claim 1, wherein said combination neural network comprises a first neural network trained to determine the current occupancy state of the seat based on data from at least some of said transducers and a second neural network trained to determine whether the data set representing the current occupancy state of the seat and formed from data from said transducers is similar to a data set on which said first neural network is trained whereby said second neural network prevents unreasonable data sets from being input to said first neural network.

11. The vehicle of claim 1, wherein said combination neural network comprises a first neural network trained to determine whether the occupying item is a child seat based on data from at least some of said transducers, a second neural network trained to determine the orientation of the child seat based on data from at least some of said transducers when said first neural network determines that the occupying item is a child seat.

12. The vehicle of claim 11, wherein said combination neural network comprises a third neural network trained to determine the position of the child seat based on data from at least some of said transducers.

13. The vehicle of claim 1, wherein said combination neural network comprises a plurality of neural networks each trained to determine the occupancy state of the seat based on data from a respective set of said transducers whereby each set of transducers is different than other sets of transducers, said processor means being arranged to factor the determination of the occupancy states by said plurality of neural networks in the determination of the occupancy state of the seat.

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14. The vehicle of claim 1, wherein said transducers include at least two ultrasonic sensors capable of receiving waves at least from a space above the seat, each of said ultrasonic sensors being arranged at a different location.

15. The vehicle of claim 14, wherein a first one of said two ultrasonic sensors is arranged on or adjacent to a ceiling of the vehicle and a second one of said two ultrasonic sensors is arranged at a different location in the vehicle such that an axis connecting said first and second ultrasonic sensors is substantially parallel to a second axis traversing a volume in the vehicle above the seat.

16. The vehicle of claim 14, wherein the system further comprises horns or grills for adjusting the transducer field angles of said ultrasonic sensors.

17. The vehicle of claim 1, wherein said transducers include four ultrasonic sensors capable of receiving waves at least from a space above the seat, said ultrasonic sensors being arranged at corners of an approximate rhombus which surrounds the seat.

18. The vehicle of claim 1, wherein said transducers include a plurality of ultrasonic sensors capable of transmitting waves at least into a space above the seat and receiving waves at least from the space above the seat, each of said ultrasonic sensors being arranged at a different location, said ultrasonic sensors having different transmitting and receiving frequencies and being arranged in the vehicle such that sensors having adjacent transmitting and receiving frequencies are not within a direct ultrasonic field of each other.

19. The vehicle of claim 1, wherein at least one of said transducers is a capacitive sensor.

20. The vehicle of claim 1, wherein said transducers are selected from a group consisting of seat belt buckle sensors, seatbelt payout sensors, infrared sensors, inductive sensors and radar sensors.

21. The vehicle of claim 1, wherein at least one of said transducers comprises a weight sensor for measuring the weight applied onto the seat.

22. The vehicle of claim 1, wherein said transducers are selected from a reclining angle detecting sensor for detecting a tilt angle of the seat between a back portion of the seat and a seat portion of the seat, a seat position sensor for detecting the position of the seat relative to a fixed reference point in the vehicle and a heartbeat sensor for sensing a heartbeat of an occupying item of the seat.

23. The vehicle of claim 1, wherein said transducers include a force, pressure or strain gage arranged to measure the weight applied to the entire seat.

24. The vehicle of claim 23, wherein the seat includes a support structure for supporting the seat above a floor of a passenger compartment of the vehicle, said force, pressure or strain gage being attached to the support structure.

25. The vehicle of claim 1, wherein said transducers include a plurality of electromagnetic wave sensors capable of receiving waves at least from a space above the seat, each of said electromagnetic wave sensors being arranged at a different location.

26. The vehicle of claim 1, wherein said transducers include wave-receiving sensors capable of receiving waves modified by passing through a space above the seat.

27. The vehicle of claim 26, wherein at least one of said wave-receiving sensors is a capacitive sensor.

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28. A method of developing a system for determining the occupancy state of a seat in the vehicle occupied by at least one occupying item, comprising the steps of:

mounting transducers in the vehicle;

forming at least one database comprising multiple data sets, each of the data sets representing a different occupancy state of the seat and being formed by receiving data from the transducers while the seat is in that occupancy state, and processing the data received from the transducers;

creating a combination neural network from the at least one database capable of producing an output indicative of the occupancy state of the seat upon inputting a data set representing an occupancy state of the seat; and

inputting a data set representing the current occupancy state of the seat into the combination neural network to obtain the output indicative of the current occupancy state of the seat.

29. The method of claim 28, wherein the step of creating the combination neural network comprises the step of training a neural network to determine the type of the occupying item based on data from at least some of the transducers.

30. The method of claim 28, wherein the step of creating the combination neural network comprises the step of training a neural network to determine the size of the occupying item based on data from at least some of the transducers.

31. The method of claim 28, wherein the step of creating the combination neural network comprises the step of training a neural network to determine the position of the occupying item based on data from at least some of the transducers.

32. The method of claim 28, wherein the step of creating the combination neural network comprises the steps of training a first neural network to determine the type of the occupying item based on data from at least some of the transducers and training a second neural network to determine the size of the occupying item based on data from at least some of the transducers.

33. The method of claim 32, wherein the step of creating the combination neural network comprises the step of training a plurality of additional neural networks to determine the position of the occupying item for a respective, different size of occupying item based on data from at least some of the transducers.

34. The method of claim 33, wherein the step of creating the combination neural network further comprises the step of training the additional neural networks to consider the position of the occupying item at a prior time when determining the position for the current occupancy state.

35. The method of claim 28, wherein the step of creating the combination neural network comprises the steps of training a first neural network to identify the occupying item based on data from at least some of the transducers and training a second neural network to determine the position of the identified occupying item based on data from at least some of the transducers.

36. The method of claim 28, wherein the step of creating the combination neural network comprises the steps of training a first neural network to determine the current occupancy state of the seat based on data from at least some of the transducers and training a second neural network to determine whether the data set representing the current occupancy state of the seat and formed from data from the transducers is similar to a data set on which the first neural network is trained whereby the second neural network prevents unreasonable data sets from being input to the first neural network.

37. The method of claim 28, wherein the step of creating the combination neural network comprises the steps of training a first neural network to determine whether the occupying item is a child seat based on data from at least some of the transducers, and training a second neural network to determine the orientation of the child seat based on data from at least some of the transducers when the first neural network determines that the occupying item is a child seat.

38. The method of claim 37, wherein the step of creating the combination neural network further comprises the step of training a third neural network to determine the position of the child seat based on data from at least some of the transducers.

39. The method of claim 28, wherein the step of creating the combination neural network comprises the steps of training a plurality of neural networks to determine the occupancy state based on data from a respective set of the transducers whereby each set of transducers is different than other sets of transducers, further comprising the step of factoring the determination of the occupancy states by the plurality of neural networks in the determination of the occupancy state.

40. The method of claim 28, further comprising the step of:

pre-processing the data prior to processing the data to form the data sets.

41. The method of claim 40, wherein the pre-processing step comprises the step of using data created from features of the data in the data set.

42. The method of claim 28, further comprising the step of:

biasing the combination neural network toward a particular occupancy state thereby increasing the accuracy of identifying that occupancy state.

43. The method of claim 28, wherein the step of creating the combination neural network further comprises the step of training the combination neural network to consider the occupancy state at a prior time when determining the current occupancy state.

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44. A method of developing a database for use in developing a system for determining the occupancy state of a vehicle seat by an occupying item, comprising the steps of:

mounting transducers in the vehicle;

providing the seat with an initial occupancy state;

receiving data from the transducers;

processing the data from the transducers to form a data set representative of the initial occupancy state of the vehicle seat;

changing the occupancy state of the seat and repeating the data collection process to form another data set;

collecting at least 1000 data sets into a first database, each data set representing a different occupancy state of the seat;

creating a combination neural network from the first database which correctly identifies the occupancy state of the seat for most of the data sets in the first database;

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testing the combination neural network using a second database of data sets which were not used in the creation of the combination neural network;

identifying the occupancy states in the second database which were not correctly identified by the combination neural network;

collecting new data comprising similar occupancy states to the incorrectly identified states;

combining this new data with the first database;

creating a new combination neural network based on the combined database; and

repeating this process until the desired accuracy of the combination neural network is achieved.

45. The method of claim 44, wherein the step of creating the combination neural network comprises the step of training a neural network to determine the type of the occupying item based on data from at least some of the transducers.

46. The method of claim 44, wherein the step of creating the combination neural network comprises the step of training a neural network to determine the size of the occupying item based on data from at least some of the transducers.

47. The method of claim 44, wherein the step of creating the combination neural network comprises the step of training a neural network to determine the position of the occupying item based on data from at least some of the transducers.

48. The method of claim 44, wherein the step of creating the combination neural network comprises the steps of training a first neural network to determine the type of the occupying item based on data from at least some of the transducers and training a second neural network to determine the size of the occupying item based on data from at least some of the transducers.

49. The method of claim 48, wherein the step of creating the combination neural network comprises the step of training a plurality of additional neural networks to determine the position of the occupying item for a respective, different size of occupying item based on data from at least some of the transducers.

50. The method of claim 49, wherein the step of creating the combination neural network further comprises the step of training the additional neural networks to consider the position of the occupying item at a prior time when determining the position for the current occupancy state.

51. The method of claim 44, wherein the step of creating the combination neural network comprises the steps of training a first neural network to identify the occupying item based on data from at least some of the

transducers and training a second neural network to determine the position of the identified occupying item based on data from at least some of the transducers.

52. The method of claim 44, wherein the step of creating the combination neural network comprises the steps of training a first neural network to determine the current occupancy state of the seat based on data from at least some of the transducers and training a second neural network to determine whether the data set representing the current occupancy state of the seat and formed from data from the transducers is similar to a data set on which the first neural network is trained whereby the second neural network prevents unreasonable data sets from being input to the first neural network.

53. The method of claim 44, wherein the step of creating the combination neural network comprises the steps of training a first neural network to determine whether the occupying item is a child seat based on data from at least some of the transducers, and training a second neural network to determine the orientation of the child seat based on data from at least some of the transducers when the first neural network determines that the occupying item is a child seat.

54. The method of claim 53, wherein the step of creating the combination neural network further comprises the step of training a third neural network to determine the position of the child seat based on data from at least some of the transducers.

55. The method of claim 44, wherein the step of creating the combination neural network comprises the steps of training a plurality of neural networks to determine the occupancy state of the seat based on data from a respective set of the transducers whereby each set of transducers is different than other sets of transducers, further comprising the step of factoring the determination of the occupancy states by the plurality of neural networks in the determination of the occupancy state.

56. The method of claim 44, wherein the step of creating the combination neural network comprises the step of training a plurality of neural networks to perform a respective, different function.

57. The method of claim 56, wherein the step of creating the combination neural network comprises the step of training the plurality of neural networks on different data sets of the first database.

58. The method of claim 44, further comprising the step of:

pre-processing the data prior to processing the data to form the data sets.

59. The method of claim 58, wherein the pre-processing step comprises the step of using data created from features of the data in the data set.

60. The method of claim 44, further comprising the step of:

biasing the combination neural network toward a particular occupancy state thereby increasing the accuracy of identifying that occupancy state.

61. The method of claim 44. further comprising the step of:

creating some of the occupancy states of the seat using live human beings.

62. The method of claim 44, further comprising the step of:

varying the environmental conditions inside the vehicle while data is being collected.

63. The method of claim 62, wherein the environmental conditions varying step comprises the step of creating thermal gradients within the passenger compartment.

64. The method of claim 44, wherein the varying occupancy states are created by automatically moving various vehicle complements such as the seat and seatback during the data collection process.

65. The method of claim 44, further comprising the step of:

validating proper functioning of the transducers and the data collection process by using a standard occupancy state of the seat and corresponding prerecorded data set, wherein a data set is periodically taken of the standard occupancy state and compared with the prerecorded data set.

66. The method of claim 44, wherein the step of creating the combination neural network the step of training the combination neural network to consider the occupancy state at a prior time when determining the current occupancy state.

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67. A method of developing a system for determining the occupancy state of a vehicle seat in a passenger compartment of a vehicle, comprising the steps of:

mounting a set of transducers on the vehicle;

receiving data from the transducers;

processing the data from transducers to form a data set representative of the occupancy state of the vehicle;

forming a database comprising multiple data sets;

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creating a combination neural network from the database capable of producing an output indicative of the occupancy state of the vehicle seat upon inputting a new data set;

developing a measure of system accuracy;

removing at least one of the transducers from the transducer set;

creating a new database containing data only from the reduced number of transducers;

creating a new combination neural network based on the new database;

testing the new combination neural network to determine the new system accuracy; and

continuing the process of removing transducers, combination neural network creation and testing until the minimum number of sensors is determined which produces a combination neural network having desired accuracy.

68. The method of claim 67, wherein the transducers are selected from a group consisting of ultrasonic transducers, optical sensors, capacitive sensors, weight sensors, seat position sensors, seatback position sensors, seat belt buckle sensors, seatbelt payout sensors, infrared sensors, inductive sensors and radar sensors.

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69. A vehicle including a system for determining the occupancy state of a seat in the vehicle occupied by an occupying item, the system comprising:

a plurality of transducers arranged in the vehicle, each of said transducers providing data relating to the occupancy state of the seat; and

a processing unit coupled to said transducers for receiving the data from said transducers and processing the data to obtain an output indicative of the current occupancy state of the seat, a combination neural network created from a plurality of data sets being resident in said processing unit, each of said data sets representing a different occupancy state of the seat and being formed from data from said transducers while the seat is in that occupancy state,

said combination neural network providing the output indicative of the current occupancy state of the seat upon inputting a data set representing the current occupancy state of the seat and being formed from data from at least some of said transducers.

70. The vehicle of claim 69, wherein said combination neural network comprises at least one neural network trained to determine at least one of the type, size and position of the occupying item based on data from at least some of said transducers.

71. The vehicle of claim 69, wherein said combination neural network comprises a first neural network trained to identify the occupying item based on data from at least some of said transducers and a second neural network trained to determine the position of the occupying item based on data from at least some of said transducers.

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72. The vehicle of claim 69, wherein said combination neural network comprises a first neural network trained to determine the current occupancy state of the seat based on data from at least some of said transducers and a second neural network trained to determine whether the data set representing the current occupancy state of the seat and formed from data from said transducers is similar to a data set on which said first neural network is trained whereby said second neural network prevents unreasonable data sets from being input to said first neural network.

73. The vehicle of claim 69, wherein said combination neural network comprises a first neural network trained to determine whether the occupying item is a child seat based on data from at least some of said transducers, a second neural network trained to determine the orientation of the child seat based on data from at least some of said transducers when said first neural network determines that the occupying item is a child seat.

74. The vehicle of claim 73, wherein said combination neural network comprises a third neural network trained to determine the position of the child seat based on data from at least some of said transducers.

75. The vehicle of claim 69, wherein said combination neural network comprises a plurality of neural networks each trained to determine the occupancy state of the seat based on data from a respective set of said transducers whereby each set of transducers is different than other sets of transducers, said processor means being arranged to factor the determination of the occupancy states by said plurality of neural networks in the determination of the occupancy state of the seat.

76. The vehicle of claim 69, wherein said transducers include a plurality of electromagnetic wave sensors capable of receiving waves at least from a space above the seat, each of said electromagnetic wave sensors being arranged at a different location.

77. The vehicle of claim 69, wherein said transducers include wave-receiving sensors capable of receiving waves modified by passing through a space above the seat.

78. The vehicle of claim 77, wherein at least one of said wave-receiving sensors is a capacitive sensor.

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